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PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing *(day/month/year)*	23.03.2006

Applicant's or agent's file reference	IMPORTANT NOTIFICATION
38735/SM/p	

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP2004/009973	07.09.2004	07.11.2003

Applicant
URETEK S.R.L. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

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PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 38735/SM/p	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/EP2004/009973	International filing date *(day/month/year)* 07.09.2004	Priority date *(day/month/year)* 07.11.2003
International Patent Classification (IPC) or both national classification and IPC INV. E02D3/12 E02D29/02		
Applicant URETEK S.R.L. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 13 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☒ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
06.06.2005	23.03.2006
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Nilsson, L Telephone No. +49 89 2399-2460

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP2004/009973

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1-5, 7-28	as originally filed
6, 6a	filed with telefax on 07.09.2005

Claims, Numbers

1-72	filed with telefax on 07.09.2005

Drawings, Sheets

1/7-7/7	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

II. Priority

1. ☒ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:

   ☒ copy of the earlier application whose priority has been claimed.

   ☐ translation of the earlier application whose priority has been claimed.

2. ☐ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid.

   Thus for the purposes of this opinion, the international filing date indicated above is considered to be the relevant date.

3. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	6-72
	No:	Claims	1-5
Inventive step (IS)	Yes:	Claims	
	No:	Claims	6-72
Industrial applicability (IA)	Yes:	Claims	1-72
	No:	Claims	

2. Citations and explanations

   see separate sheet

INTERNATIONAL PRELIMINARY EXAMINATION REPORT - SEPARATE SHEET

International application No. PCT/EP2004/009973

Re Item V.

1) The following documents are referred to in this communication:
   D1 : PATENT ABSTRACTS OF JAPAN vol. 0180, no. 44 (M-1547), 24 January 1994 (1994-01-24) &; JP 5 272126 A (OKABE CO LTD), 19 October 1993 (1993-10-19)
   D2 : EP 0 851 064 A (URETEK S R L) 1 July 1998 (1998-07-01)
   D3 : EP 1 314 824 A (URETEK S R L) 28 May 2003 (2003-05-28)
   D4 : GB 2 135 721 A (GKN KELLER GMBH) 5 September 1984 (1984-09-05)
   D5 : PATENT ABSTRACTS OF JAPAN vol. 0176, no. 67 (M-1524), 9 December 1993 (1993-12-09) &; JP 5 222717 A (OKABE CO LTD), 31 August 1993 (1993-08-31)
   D6 : PATENT ABSTRACTS OF JAPAN vol. 0145, no. 19 (M-1048), 14 November 1990 (1990-11-14) &; JP 2 217518 A (SHIMIZU CORP), 30 August 1990 (1990-08-30)

2) The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.
   Document D1 discloses (the references in parenthesis applying to this document):

   A method for increasing the strength of a volume of soil, whereby it comprises at least one reinforcement step that comprises the following steps:
   - a step for preparing receptacles for a reinforcement structure, in which a plurality of mutually spaced reinforcement holes are formed, said holes being arranged substantially vertically or inclined with respect to vertical direction (this feature cover all angels from 0-360 degrees with respect to the vertical) in the volume of soil to be strengthened (it is obvious that in the method in D1 not only one hole is drilled but a plurality thereof);
   - a step for inserting the reinforcement structure, during which reinforcement elements are inserted in said reinforcement holes (in D1 a "hollow rod" 1 is inserted into and left in the drilled hole, see for example figure 16);
   - a step for locking the reinforcement structure, during which a synthetic locking substance that expands pa chemical reaction is injected into said reinforcement holes, said substance being adapted to bond said reinforcement elements with the surrounding soil (a urethane foam resin is injected into the hole, said resin is then

foamed and hardened).

3) Dependent claims 2-5 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step (Article 33(2) and (3) PCT).

4) Inasmuch as the features of dependent claims 6-72 are not directly known from D1, they obviously concern only minor modifications thereto which come within the customary practice followed by a person skilled in the art and which cannot therefore be regarded as inventive (Article 33 (3) PCT).
Consequently, dependent claims 6-72 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, involve an inventive step.

supporting structures.

Moreover, a method is known by means of which the excavation faces are supported by steel sheet piles that are driven well below the maximum excavation depth, before performing said excavation, by means of vibration systems. This method sometimes cannot be applied, since the machines required for the installation are large and the vibrations produced during driving can damage nearby buildings.

Another known method for supporting the excavation face is constituted by the use of nails of different lengths, which are driven into the ground at right angles to the face directly after providing an excavation or a portion of an excavation. Said nails are adapted to increase the shear strength of the soil behind the face. However, in the time interval between execution of the excavation and nail driving, an unexpected instability may occur which can lead to the collapse of the face or of part of said face. In general, in any case, this method, known as "soil nailing", entails the use of large machines and high installation costs.

Another known method consists of injecting cement mixes into the soil proximate to the face to be provided, in order to increase the shear strength of the soil. This method, known as "jet grouting", requires high injection pressures (300-600 bar) for correct execution. These pressures may cause migration of the injected cement mixture into volumes of soil that are distant from the intended ones, causing considerable damage to nearby buildings. Moreover, this technology can be applied only to granular soil. These characteristics, together with high installation costs, limit considerably the application of this method in the urban environment.

Disclosure of the Invention

The aim of the present invention is to provide a method for increasing the resistance to all the various stresses of a portion (or band) of soil, particularly for containing and supporting excavation faces, that is capable of solving the problems noted above with reference to known types of

(*) insert page 6a

In addition is also known providing a soil consolidation hole that is filled with foamed urethane. See in this respect Patent Abstract of Japan vol. 0180, no 44, 24 Jan. 1994 & JP 5 272126A (Okabe Co Ltd) and Patent Abstract of Japan vol. 0176, no. 67 (09.12.1993) & JP 5 222717 (Okabe Co Ltd).

Load bearing capacity increasing for subsided or loose soil masses by injection of expanding and hardening substances in holes made in the soil to be treated is described in EP-A-0 851 064, EP-A- 1 314 824 and GB 2 135 721 A.

Patent Abstracts of Japan vol. 0145, no. 19 (14.12.1990) & JP 2 217518 (Shimizu Corp.) describes a reinforcement technique based on application of a plastic material grid 5 supported on earth inserted bolts 4 and covered with mortar 6.

None of such documents regards an excavation face reinforcement method.

CLAIMS

1. A method for increasing the strength of a volume of soil, particularly for containing and supporting excavation faces, ~~characterized in that it comprises~~ comprising at least one reinforcement step that comprises the following steps:

- a step for preparing receptacles for a reinforcement structure, in which a plurality of mutually spaced reinforcement holes are formed, said holes being arranged substantially vertically or inclined with respect to a vertical direction in the volume of soil to be strengthened;
- a step for inserting the reinforcement structure, during which reinforcement elements are inserted in said reinforcement holes;
- a step for locking the reinforcement structure, during which a synthetic locking substance that expands by chemical reaction is injected into said reinforcement holes, said substance being adapted to bond said reinforcement elements with the surrounding soil.

2. The method according to claim 1, characterized in that said reinforcement holes and said reinforcement elements are inclined with respect to the vertical on a plane that is parallel to the excavation face.

3. The method according to claim 1, characterized in that said reinforcement holes and said reinforcement elements are inclined with respect to the vertical on a vertical plane that is perpendicular to the excavation face.

4. The method according to claim 1, characterized in that said reinforcement holes and said reinforcement elements are inclined with respect to the vertical on a plane that is parallel to the excavation face and on a vertical plane that is perpendicular to the excavation face.

5. The method according to one or more of the preceding claims, characterized in that said reinforcement holes and said reinforcement elements are inclined with respect to the vertical toward the volume of soil to be strengthened.

6. The method according to one or more of the preceding claims, characterized in that said reinforcement holes are provided at a distance from the excavation face to be produced or from the exposed face of the volume of soil to be strengthened that is substantially comprised between 0.10 m and 2.00 m.

7. The method according to one or more of the preceding claims, characterized in that the distance between two contiguous reinforcement holes is substantially comprised between 0.20 m and 2 m.

8. The method according to one or more of the preceding claims, characterized in that said reinforcement holes have a diameter that is substantially comprised between 12 mm and 180 mm.

9. The method according to one or more of the preceding claims, characterized in that said reinforcement holes are arranged, in plan view, in rows that are substantially parallel to the excavation face or to the exposed face of the volume of soil to be strengthened.

10. The method according to one or more of the preceding claims, characterized in that the distance between two contiguous rows of said reinforcement holes is substantially comprised between 0.10 m and 2.00 m.

11. The method according to one or more of the preceding claims, characterized in that said reinforcement holes and/or said reinforcement elements have such a length as to pass through the natural lie of the excavation face or the deep slip surface of the volume of soil to be strengthened.

12. The method according to one or more of the preceding claims, characterized in that said reinforcement holes and/or said reinforcement elements have such a length as to penetrate for at least 0.5 m in the soil that lies below the natural lie of the excavation face or the deep slip surface of the volume of soil to be strengthened.

13. The method according to one or more of the preceding claims, characterized in that said reinforcement elements have a tensile strength of

more than 5 MPa.

14. The method according to one or more of the preceding claims, characterized in that said reinforcement elements have a shear strength of more than 0.3 MPa.

15. The method according to one or more of the preceding claims, characterized in that said reinforcement elements are constituted, for each one of said reinforcement holes, by a bar that can be inserted in the corresponding reinforcement hole.

16. The method according to one or more of the preceding claims, characterized in that said bar has a solid cross-section whose diameter is smaller than the corresponding reinforcement hole.

17. The method according to one or more of the preceding claims, characterized in that said bar is constituted by a tubular element with openings on its side surface, said tubular element having a diameter that is smaller than, or equal to, the diameter of the corresponding reinforcement hole.

18. The method according to one or more of the preceding claims, characterized in that said tubular elements that constitute said reinforcement elements have an outside diameter that is substantially comprised between 12 mm and 180 mm and an inside diameter that is substantially comprised between 8 mm and 150 mm.

19. The method according to one or more of the preceding claims, characterized in that the lateral openings formed in the lateral surface of said tubular elements that constitute the reinforcement elements occupy at least 30% of the lateral surface of said tubular elements.

20. The method according to one or more of the preceding claims, characterized in that during said locking step the synthetic locking substance is injected into the reinforcement holes laterally to the corresponding reinforcement element.

21. The method according to one or more of the preceding claims,

characterized in that during said locking step the synthetic locking substance is injected into the reinforcement holes inside the corresponding tubular element that constitutes the reinforcement bar.

22. The method according to one or more of the preceding claims, characterized in that the upper end of said reinforcement elements is anchored to the soil located outside the thrust wedge or to the foundation structure of an existing building that is crossed by said reinforcement holes.

23. The method according to one or more of the preceding claims, characterized in that it comprises a step for consolidating the volume of soil to be strengthened, said step comprising the following steps:

- a drilling step, in which a plurality of injection holes (1) are produced, said holes (1) being mutually spaced and being arranged substantially vertically or inclined (2) with respect to a vertical direction within the volume of soil whose resistance to all the various stresses is to be increased;
- an injection step, in which a synthetic consolidation substance (3) is injected into said injection holes (1), said substance expanding by chemical reaction and being adapted to compact, as a consequence of its expansion, the surrounding soil.

24. The method according to ~~one or more of the preceding claims~~ claim 23, characterized in that said injection holes (1) are produced at a distance from the excavation face to be produced or from the exposed face of the volume of soil (2) to be strengthened that is substantially comprised between 0.10 m and 2.00 m.

25. The method according to ~~one or more of the preceding~~ claims 23 or 24, characterized in that the distance between two contiguous injection holes (1) is substantially comprised between 0.20 m and 2 m.

26. The method according to one or more of the ~~preceding~~ claims 23-25, characterized in that said injection holes have a diameter substantially comprised between 12 mm and 180 mm.

27. The method according to one or more of the ~~preceding~~ claims 23-26,

characterized in that said injection holes (1) are arranged, in plan view, in rows that are substantially parallel to the excavation face or to the exposed face of the volume of soil to be strengthened.

28. The method according to one or more of the ~~preceding~~ claims 23-27, characterized in that the distance between two contiguous rows of said injection holes is substantially comprised between 0.10 m and 2.00 m.

29. The method according to one or more of the ~~preceding~~ claims 23-28, characterized in that in said injection step and/or in said locking step, the synthetic substance is injected by means of injection tubes (4) that are inserted in the corresponding injection holes (1) and/or in the corresponding reinforcement holes (5), gradually extracting the injection tube (4) from the corresponding injection hole and/or from the corresponding reinforcement hole.

30. The method according to one or more of the ~~preceding~~ claims 23-29, characterized in that said injection tubes used in said consolidation step and/or in said reinforcement step have a diameter that is substantially comprised between 6 mm and 30 mm.

31. The method according to one or more of the ~~preceding~~ claims 23-30, characterized in that at least the outer surface of said injection tubes used in said consolidation step and/or in said reinforcement step is made of, or treated with, a lubricating substance in order to facilitate its extraction from said injection holes and/or from said reinforcement holes.

32. The method according to one or more of the ~~preceding~~ claims 23-31, characterized in that the rate of extraction of the injection tube from the corresponding injection hole and/or from the corresponding reinforcement hole and/or the flow rate of synthetic substance delivered during extraction in said injection step or in said locking step is changed according to the stratigraphic characteristics of the soil crossed by the injection hole and/or by the reinforcement hole in order to deliver larger quantities of synthetic substance in weaker layers of the soil and smaller quantities of synthetic

substance in stronger layers of the soil.

33. The method according to one or more of the preceding claims, characterized in that the injection pressure of said synthetic substance is substantially comprised between 5 and 30 bar.

34. The method according to one or more of the preceding claims, characterized in that said synthetic substance has a modulus of elasticity on the same order of magnitude as the modulus of elasticity of the soil in which it is injected, i.e., less than 500 MPa.

35. The method according to one or more of the preceding claims, characterized in that the chemical expansion reaction of said synthetic substance is not affected by the presence of water in the surrounding soil.

36. The method according to one or more of the preceding claims, characterized in that said synthetic substance, after expansion, cannot be altered by the presence of water in the surrounding soil.

37. The method according to one or more of the preceding claims, characterized in that said synthetic substance is constituted by a closed-cell polyurethane foam.

38. The method according to one or more of the preceding claims, characterized in that said synthetic substance is constituted by an MDI isocyanate and by a mixture of polyols.

39. The method according to one or more of the ~~preceding~~ claims 23-38, characterized in that said consolidation step is performed before said reinforcement step.

40. The method according to one or more of the ~~preceding~~ claims 23-39, characterized in that said synthetic consolidation substance has a potential volume increase substantially comprised between 2 and 30 times the volume of said synthetic substance prior to expansion.

41. The method according to one or more of the ~~preceding~~ claims 23-40, characterized in that said synthetic consolidation substance has a potential volume increase substantially comprised between 5 and 30 times the volume

of said synthetic substance prior to expansion.

42. The method according to one or more of the ~~preceding~~ claims 23-41, characterized in that said synthetic consolidation substance has a reaction time substantially comprised between 2 and 80 seconds.

43. The method according to one or more of the ~~preceding~~ claims 23-42, characterized in that said synthetic consolidation substance has a reaction time substantially comprised between 2 and 15 seconds.

44. The method according to one or more of the ~~preceding~~ claims 23-43, characterized in that said synthetic consolidation substance has a maximum expansion pressure that is higher than the tension in the volume of soil to be strengthened.

45. The method according to one or more of the ~~preceding~~ claims 23-44, characterized in that said synthetic consolidation substance has a maximum expansion pressure, in fully confined conditions, that is substantially comprised between 200 KPa and 10,000 KPa.

46. The method according to one or more of the ~~preceding~~ claims 23-45, characterized in that said synthetic consolidation substance has a maximum expansion pressure of substantially more than 500 KPa.

47. The method according to one or more of the ~~preceding~~ claims 23-46, characterized in that said synthetic consolidation substance, prior to the chemical expansion reaction, has a viscosity substantially comprised between 100 mPa·s and 700 mPa·s at 25° C.

48. The method according to one or more of the ~~preceding~~ claims 23-47, characterized in that the viscosity of said synthetic consolidation substance passes from a value comprised between 100 mPa·s and 700 mPa·s to a value that tends to infinity in a time interval comprised between 5 and 20 seconds starting from the beginning of the chemical expansion reaction.

49. The method according to one or more of the ~~preceding~~ claims 23-48, characterized in that said synthetic consolidation substance has, after expansion, in conditions in which expansion is not confined, a density of

substantially 30 Kg/m³.

50. The method according to one or more of the ~~preceding~~ claims 23-49, characterized in that said synthetic consolidation substance, once injected into the soil and hardened, has a density substantially comprised between 100 Kg/m³ and 400 Kg/m³.

51. The method according to one or more of the ~~preceding~~ claims 23-50, characterized in that said synthetic consolidation substance, once injected and hardened, has a tensile strength that is substantially comprised between 0.75 MPa and 5.50 MPa respectively at the densities of 100 kg/m³ and 400 kg/m³.

52. The method according to one or more of the ~~preceding~~ claims 23-51, characterized in that said synthetic consolidation substance, once injected and hardened, has a compressive strength that is substantially comprised between 0.68 MPa and 8.78 MPa respectively at the densities of 100 kg/m³ and 400 Kg/m³.

53. The method according to one or more of the ~~preceding~~ claims 23-52, characterized in that said synthetic consolidation substance, once injected and hardened, has a flexural strength that is essentially comprised between 0.95 MPa and 6.00 MPa respectively at the densities of 100 kg/m³ and 400 kg/m³.

54. The method according to one or more of the ~~preceding~~ claims 23-53, characterized in that the synthetic consolidation substance, once injected and hardened, has a shear strength substantially comprised between 0.34 MPa and 4.39 MPa respectively at the densities of 100 kg/m³ and 400 kg/m³.

55. The method according to one or more of the ~~preceding~~ claims 23-54, characterized in that said synthetic locking substance has a potential volume increase substantially comprised between 1 and 5 times the volume of said synthetic substance prior to expansion.

56. The method according to one or more of the ~~preceding~~ claims 23-55,

characterized in that said synthetic locking substance has a reaction time substantially comprised between 2 and 80 seconds.

57. The method according to one or more of the preceding claims 23-56, characterized in that said synthetic locking substance has a maximum expansion pressure that is lower than the limit breaking pressure of the contiguous soil affected by the consolidation step.

58. The method according to one or more of the preceding claims, characterized in that said synthetic locking substance has a significant decrease in the maximum expansion pressure (dissipation) following a degree of expansion thereof of 5%, or less.

59. The method according to one or more of the preceding claims, characterized in that said synthetic locking substance has a maximum expansion pressure, in fully confined conditions, that is comprised between 20 KPa and 200 KPa.

60. The method according to one or more of the preceding claims, characterized in that said synthetic locking substance, prior to the chemical expansion reaction, has a viscosity substantially comprised between 100 mPa·s and 500 mPa·s at 25° C.

61. The method according to one or more of the preceding claims, characterized in that the viscosity of said synthetic locking substance passes from a value comprised between 100 mPa·s and 500 mPa·s at 25° C to a value that tends to infinity in a time interval comprised between 10 and 80 seconds starting from the beginning of the chemical expansion reaction.

62. The method according to one or more of the preceding claims, characterized in that said synthetic locking substance has, after expansion, in non-confined expansion conditions, a density of at least 200 Kg/m^3.

63. The method according to one or more of the preceding claims, characterized in that said synthetic locking substance, once injected into the soil and hardened, has a density substantially comprised between 400 Kg/m^3 and 800 Kg/m^3.

64. The method according to one or more of the preceding claims, characterized in that said synthetic locking substance, once injected and hardened, has a tensile strength substantially comprised between 5.60 MPa and 17.80 mPa respectively at the densities of 400 kg/m^3 and 800 kg/m^3.

65. The method according to one or more of the preceding claims, characterized in that said synthetic locking substance, once injected and hardened, has a compressive strength substantially comprised between 8.78 MPa and 34.42 MPa respectively at the densities of 400 kg/m^3 and 800 kg/m^3.

66. The method according to one or more of the preceding claims, characterized in that said synthetic locking substance, once injected and hardened, has a flexural strength substantially comprised between 7.18 MPa and 11.98 MPa respectively at the densities of 400 kg/m^3 and 800 kg/m^3.

67. The method according to one or more of the preceding claims, characterized in that said synthetic locking substance, once injected and hardened, has a shear strength substantially comprised between 4.40 MPa and 17.20 MPa respectively at the densities of 400 kg/m^3 and 800 kg/m^3.

68. The method according to one or more of the ~~preceding~~ 23-67 claims, characterized in that said consolidation step is performed substantially simultaneously with said reinforcement step.

69. The method according to one or more of the ~~preceding~~ 23-68 claims, characterized in that said consolidation step is performed substantially simultaneously with said reinforcement step by producing said reinforcement holes and said injection holes, inserting in said reinforcement holes said reinforcement elements and then injecting said synthetic consolidation substance into said injection holes and said synthetic locking substance into said reinforcement holes.

70. The method according to one or more of the ~~preceding~~ 23-69 claims, characterized in that the synthetic locking substance used in said reinforcement step, in the absence of said consolidation step or when

performing said reinforcement step substantially simultaneously with said consolidation step, has a maximum expansion pressure, in fully confined conditions, comprised between 20 KPa and 10,000 KPa.

71. The method according to one or more of the ~~preceding~~ claims 23-70, characterized in that the synthetic locking substance used in said reinforcement step, in the absence of said consolidation step or when performing said reinforcement step substantially simultaneously with said consolidation step, once injected into the soil and hardened, has a density substantially comprised between 250 kg/m^3 and 400 kg/m^3.

72. The method according to one or more of the ~~preceding~~ claims 23-71, characterized in that the synthetic locking substance injected into the reinforcement holes in said reinforcement step, in the absence of said consolidation step or when performing said reinforcement step substantially simultaneously with said consolidation step, is constituted by said synthetic consolidation substance.